**AN ORDINANCE BY**
**COUNCILMEMBER JIM MADDOX**
**AS SUBSTITUTED BY PUBLIC SAFETY**
**AND LEGAL ADMINISTRATION COMMITTEE** **05-O-1090**

**AN ORDINANCE TO AMEND CHAPTER 150 OF THE CODE OF ORDINANCE OF THE CITY OF ATLANTA BY CREATING A NEW SECTION 150-69 WHICH SHALL PROVIDE THAT IT SHALL BE UNLAWFUL TO USE A HAND-HELD MOBILE TELEPHONE WHILE OPERATING A MOTOR VEHICLE IN THE CITY OF ATLANTA; AND FOR OTHER PURPOSES**

**WHEREAS**, the use of mobile telephones has skyrocketed in recent years, with more than 117 million subscribers in the United States as of July 1, 2001; and

**WHEREAS**, this increase has been accompanied by an increase in the number of individuals concurrently driving and talking on the cell phone. Recent estimates suggest that cell phone users spend 60% of their cell phone time while driving; and

**WHEREAS**, research makes the tacit assumption that the source of any interference from cell phone use is due to peripheral factors such as dialing and holding the phone while conversing; and this assumption has been proven valid; and

**WHEREAS**, prior research has established that the use of mobile telephones impairs driving performance and is associated with an increased likelihood of serious road crashes. *See e.g.*, Donald A. Redelmeier, M.D., *Association Between Cellular-Telephone Calls and Motor Vehicle Collisions*, The New England Journal of Medicine, Volume 336, Number 7 (February 13, 1997), attached hereto as Exhibit "A"; Suzanne P. McEvoy, *Role of Mobile Phones in Motor Vehicle Crashes Resulting in Hospital Attendance: a Case-Crossover Study*, BMJ, doi:10.1136/bmj.38537.397512.55 (July 12, 2005), attached hereto as Exhibit "B".

**WHEREAS**, the idea of using hand free devices has been cautiously embraced by the cell phone industry. Some vendors, for example, encourage new buyers to use them for their own safety; and

**WHEREAS**, it is the sentiment of the Atlanta City Council that the banning of the use of handheld mobile telephones will decrease the incidence of traffic accidents and thereby improve the safety on the city's arteries; and

**WHEREAS**, similar legislation has been adopted in several states, as well as cities throughout the United States.

(b) Except as otherwise provided in this section, it shall be unlawful for any person to operate a motor vehicle upon any portion of the city's street system while using a mobile telephone to engage in a call while such vehicle is in motion.

(c) An operator of a motor vehicle who holds a mobile telephone to, or in the immediate proximity of his or her ear while such vehicle is in motion is presumed to be engaging in a call within the meaning of this section. The presumption established by this subsection is rebuttable by evidence tending to show that the operator was not engaged in a call.

(d) The provisions of this section shall not be construed as authorizing the seizure or forfeiture of a mobile telephone, unless otherwise provided by law or ordinance.

(e) Subsection (b) of this section shall not apply to:

(1) The use of a mobile telephone for the sole purpose of communicating with any of the following regarding an emergency situation: an emergency response operator; a hospital, physician's office or health clinic; an ambulance company or corps; a fire department, including any subdivision thereof; or a police department, including any subdivision thereof; or

(2) Any of the following persons while in the performance of their official duties: a police officer or peace officer; a member of a fire department; an operator of a public works vehicle; or the operator of an authorized emergency vehicle as defined in O.C.G.A. § 40-1-1(5); or

(3) The use of a hands-free mobile telephone.

(f) Any person who violates subsection (b) of this section shall be subject to a fine of $50.00, provided however, that if a violation occurs at the time of a traffic accident, the driver shall be subject to an additional fine not to exceed $200.00.

(g) In order to notify and educate the public as to the enactment of this ordinance, a sixty (60) day grace period from the ordinance's effective date shall be imposed. During such 60 day grace period, only warning citations shall be issued to persons violating subsection (b) of this section.

**Section 3:** That all ordinances and parts of ordinances in conflict herewith are hereby repealed.

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## ASSOCIATION BETWEEN CELLULAR-TELEPHONE CALLS AND MOTOR VEHICLE COLLISIONS


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### ABSTRACT

*Background* Because of a belief that the use of cellular telephones while driving may cause collisions, several countries have restricted their use in motor vehicles, and others are considering such regulations. We used an epidemiologic method, the case–crossover design, to study whether using a cellular telephone while driving increases the risk of a motor vehicle collision.

*Methods* We studied 699 drivers who had cellular telephones and who were involved in motor vehicle collisions resulting in substantial property damage but no personal injury. Each person's cellular-telephone calls on the day of the collision and during the previous week were analyzed through the use of detailed billing records.

*Results* A total of 26,798 cellular-telephone calls were made during the 14-month study period. The risk of a collision when using a cellular telephone was four times higher than the risk when a cellular telephone was not being used (relative risk, 4.3; 95 percent confidence interval, 3.0 to 6.5). The relative risk was similar for drivers who differed in personal characteristics such as age and driving experience; calls close to the time of the collision were particularly hazardous (relative risk, 4.8 for calls placed within 5 minutes of the collision, as compared with 1.3 for calls placed more than 15 minutes before the collision; $P<0.001$); and units that allowed the hands to be free (relative risk, 5.9) offered no safety advantage over hand-held units (relative risk, 3.9; P not significant). Thirty-nine percent of the drivers called emergency services after the collision, suggesting that having a cellular telephone may have had advantages in the aftermath of an event.

*Conclusions* The use of cellular telephones in motor vehicles is associated with a quadrupling of the risk of a collision during the brief period of a call. Decisions about regulation of such telephones, however, need to take into account the benefits of the technology and the role of individual responsibility. (N Engl J Med 1997;336:453-8.)




MOTOR vehicle collisions are a leading cause of death in North America; they are the single most frequent cause of death among children and young adults and account for one fatality every 10 minutes.[1-3] During an average year, about 1 person in 50 will be involved in a motor vehicle collision; 1 percent of them will die, 10 percent will be hospitalized, and 25 percent will be temporarily disabled.[4,5] Motor vehicle collisions often injure persons who are otherwise in good health. The causes of motor vehicle collisions are complicated, but error on the part of drivers contributes to over 90 percent of events.[6]

Cellular telephones can be used for placing and receiving telephone calls while in a motor vehicle. North American sales are enormous; for example, in 1995 the number of new subscribers in the United States exceeded the birth rate.[7,8] Many believe that telephones may contribute to collisions by distracting drivers,[9] and a few countries (such as Brazil, Israel, and Australia) have laws against using a cellular telephone while driving. Research with simulators suggests that use of the telephone can impair some aspects of driving performance.[10-14] However, industry-sponsored surveys have found no increased risk associated with car telephones.[15,16]

The most rigorous experimental method for testing the effects of cellular telephones on motor vehicle collisions is to assess outcomes for persons randomly assigned to use or not use the devices, but such a study would be very difficult to perform and possibly unethical. Instead, we used an epidemiolog-


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ic method, the case–crossover design, to evaluate potential associations between the use of a cellular telephone and the risk of a motor vehicle collision in real-world circumstances.

## METHODS

The study was conducted in Toronto, an urban region of 3 million people with no regulations against using a cellular telephone while driving. Persons who came to the North York Collision Reporting Centre between July 1, 1994, and August 31, 1995, during peak hours (10 a.m. to 6 p.m.) on Monday through Friday were included in the study if they had been in a collision with substantial property damage (as judged by the police). Drivers do not report to the center if the collisions involve injury, criminal activity, or the transport of dangerous goods. Drivers were excluded if they said they did not have a cellular telephone or if their billing records could not be located by May 1, 1996.

### Use of Cellular Telephones

Consenting subjects completed a brief questionnaire about their personal characteristics and the features of the collision. We collected telephone records through each person's cellular-telephone number and verified each invoice by checking the subject's full name, mailing address, and calls made to his or her home telephone number. For each record, we analyzed all telephone activity on both the day of collision and the preceding seven days, with particular attention to the time, duration, and direction (incoming or outgoing) of each call. Special note was made of contact with ambulance personnel, police, or other emergency services.

### Time of the Motor Vehicle Collision

The time of each collision was estimated from the subject's statement, police records, and telephone listings of calls to emergency services. We classified the times of collisions as "exact" when information from all three sources was available and consistent or when one source supplied no data but the remaining two agreed. Otherwise, we classified the times as "inexact" and used the earliest of the available two or three times to avoid misclassifying calls made after the collision as contributing to the event. Selecting the earliest listed time reduced the chance of finding spurious associations between telephone use and collisions. However, selecting an excessively early time could lead to the underestimation of the magnitude of any association.

### Analytic Method

We used case–crossover analysis, a technique for assessing the brief change in risk associated with a transient exposure. According to this method, each person serves as his or her own control; confounding due to age, sex, visual acuity, training, personality, driving record, and other fixed characteristics is thereby eliminated.[17] We used the pair-matched analytic approach to contrast a time period on the day of the collision with a comparable period on a day preceding the collision.[18] In this instance, case–crossover analysis would identify an increase in risk if there were more telephone calls immediately before the collision than would be expected solely as a result of chance.

### Definitions of Time Periods

We defined the hazard interval to include any telephone calls occurring during the 10 minutes before the estimated time of the collision, and tested the robustness of our results by analyzing intervals of 1, 5, and 15 minutes.[19] In the primary analysis, we compared each person's telephone activity immediately before the collision (case) to his or her activity during a control period at the same time as the hazard interval on the day before the collision (crossover). In supplementary analyses we evaluated alternative comparison days and considered intervals of an hour leading up to the collision.

### Alternative Comparison Days

We checked our estimates by repeating the calculations using four other control intervals. In the workday comparison we selected the day of the workweek preceding the collision; for example, the period just before a collision on Monday was compared with the same period on the preceding Friday. In the weekday comparison, we selected the same day one week before the collision; for example, Monday was compared with the preceding Monday. In the matching-day comparison, we selected the nearest day of the preceding week on which there was cellular-telephone activity in the predefined lead-up period before the collision. For the maximal-use-day comparison, we used the control interval from the preceding three days in which there was the greatest amount of cellular-telephone activity.

### Accounting for Intermittency of Driving

Evaluating telephone activity on the day before a collision is appropriate only if driving occurred during the control interval on that day. A pilot survey involving 100 subjects indicated that 35 percent of them did not drive during the selected period; the rules of conditional probability suggested that this degree of intermittency of driving would inflate the apparent relation between cellular-telephone use and motor vehicle collisions by a factor of 1.5 ($1 \div 0.65$).[20,21] Our estimates of relative risk were therefore divided by this factor as one way of adjusting for the intermittency of driving.

To examine the robustness of our analysis, we also tested a different adjustment that relied on individual driving patterns. To do so, between October 25 and November 28, 1996, we attempted to contact all subjects who had used their cellular telephones in the 10 minutes before the collision or the 10-minute control period. We asked each person to remember his or her driving pattern on both the day of the collision and the day before the collision. We then recalculated relative risks by limiting the analysis to subjects who were confident that they had driven a motor vehicle during both periods on both days.

### Ethical Issues

The protocol was approved by the University of Toronto Human Ethics Committee, and all participants provided informed consent. Private industry supplied telephone records but otherwise had no involvement in data collection or analysis or funding the study. Individual billing records were obtained directly from cellular-telephone carriers who provided records for 100 consecutive days of telephone use for each person and who were not told which particular date was the day of the collision. Police reports were obtained directly from police departments; they, in turn, were not provided copies of the drivers' cellular-telephone records.

### Statistical Analysis

The sample size was calculated to provide an 80 percent chance of detecting a doubling or halving of collision rates. Relative risks were estimated with methods for matched-pairs studies on the basis of exact binomial tests and conditional logistic-regression analyses.[22] Confidence intervals for the relative risks were derived with the bootstrap bias-corrected method and accounted for the uncertainty in the adjustment for intermittency of driving.[23,24] Modifications of the relative risks were assessed by comparing different subgroups, with particular attention to the prespecified contrast between hand-held cellular telephones and models that leave the hands free. All P values were two-tailed, and all relative risks were computed with 95 percent confidence intervals.

## RESULTS

We approached 5890 drivers, of whom 1064 acknowledged having a cellular telephone and 742 consented to participate in the study; the billing records of 699 of these drivers were located (Table 1). The collision times were exact for 231 subjects and inexact for 468. The group placed a total of 16,870 cellular-telephone calls and received 3643 calls during the week before the collisions (average, 3.4 calls placed and 0.7 call received per person each day). The average duration of the calls was 2.3 minutes, and 76 percent lasted 2 minutes or less (similar to cellular-telephone calling patterns elsewhere[25]). The monthly bill in U.S. currency for the average participant was $72, which was greater than that for the average subscriber in Toronto or the average subscriber in North America ($53 and $51, respectively).[26-28]

Overall, 170 subjects (24 percent) had used a cellular telephone during the 10-minute period immediately before the collision, 37 (5 percent) had used the telephone during the same period on the day before the collision, and 13 (2 percent) had used the telephone during both periods. The crude analysis indicated that cellular-telephone activity was associated with a relative risk of a motor vehicle collision of 6.5 (95 percent confidence interval, 4.5 to 9.9). The primary analysis, adjusted for intermittent driving, indicated that cellular-telephone activity was associated with a quadrupling of the risk of a motor vehicle collision (relative risk, 4.3; 95 percent confidence interval, 3.0 to 6.5).

At follow-up in 1996, we located 145 subjects, of whom 72 (50 percent) were confident that they had driven during both the hazard period and the control period. Restricting our analysis to this subgroup yielded an estimated relative risk of 7.0 (95 percent confidence interval, 3.7 to 15.5) associated with cellular-telephone use. An analysis that included the entire cohort of 699 drivers and used alternative comparison days yielded similar estimates of the relative risk of a collision (Fig. 1). All the alternative estimates of relative risk were adjusted for intermittent driving, and all were statistically significant ($P<0.001$).

The relative risk of a collision associated with using a cellular telephone was consistent among subgroups with different characteristics (Table 2). Younger drivers were at a somewhat higher relative risk when using a cellular telephone than older drivers, although the trend was not significant. In no group did cellular-telephone use have a protective effect. In particular, subjects with many years of experience in using a cellular telephone still had a significant increase in risk. The highest relative risk was found among subjects who had not graduated from high school. Telephones that allowed the hands to be free did not appear to be safer than hand-held telephones.

The increase in risk appeared to be greatest for calls made near the time of the collision, and was not statistically significant for calls made more than 15 minutes before the event (Fig. 2). The relative risk was 4.8 for calls within 5 minutes before the collision, as compared with 1.3 for calls more than 15 minutes before the collision ($P<0.001$). The risks were similar at different times of the day and of the week (Fig. 3). Estimates appeared robust when calculated with use of hazard intervals of 1, 5, or 15 minutes before the collision (relative risks, 4.7, 4.8, and 4.3, respectively), for data including exact rather than inexact times of collisions (4.0 and 4.5, respectively), and with only incoming calls or only outgoing calls included (3.0 and 3.8, respectively). The association appeared stronger for collisions on high-speed roadways than for collisions in parking lots, at gas stations, or in other low-speed locations (5.4 vs. 1.6, $P=0.014$).

A total of 5325 calls were placed and 960 calls

**TABLE 1.** CHARACTERISTICS OF 699 DRIVERS AND COLLISIONS.

| CHARACTERISTIC | NO. (%)* |
|---|---|
| Age (yr) | |
| <25 | 67 (10) |
| 25–39 | 346 (49) |
| 40–54 | 227 (32) |
| ≥55 | 59 (8) |
| Sex | |
| Male | 502 (72) |
| Female | 197 (28) |
| High-school graduation | |
| Yes | 615 (88) |
| No | 84 (12) |
| Type of job | |
| Professional | 168 (24) |
| Other | 531 (76) |
| Driving experience (yr) | |
| 0–9 | 137 (20) |
| 10–19 | 246 (35) |
| 20–29 | 188 (27) |
| ≥30 | 128 (18) |
| Cellular-telephone experience (yr) | |
| 0 or 1 | 223 (32) |
| 2 or 3 | 174 (25) |
| 4 or 5 | 158 (23) |
| ≥6 | 144 (21) |
| Type of cellular telephone | |
| Hand-held | 551 (79) |
| Hands free | 148 (21) |
| Time of collision | |
| Dawn | 19 (3) |
| Morning | 268 (38) |
| Afternoon | 248 (35) |
| Evening | 145 (21) |
| Night | 18 (3) |
| Late night | 1 (<1) |
| Day of collision | |
| Sunday | 20 (3) |
| Monday | 133 (19) |
| Tuesday | 126 (18) |
| Wednesday | 159 (23) |
| Thursday | 136 (19) |
| Friday | 113 (16) |
| Saturday | 12 (2) |
| Location of collision | |
| High-speed location | 597 (85) |
| Low-speed location | 102 (15) |

*Because of rounding, percentages do not always total 100.

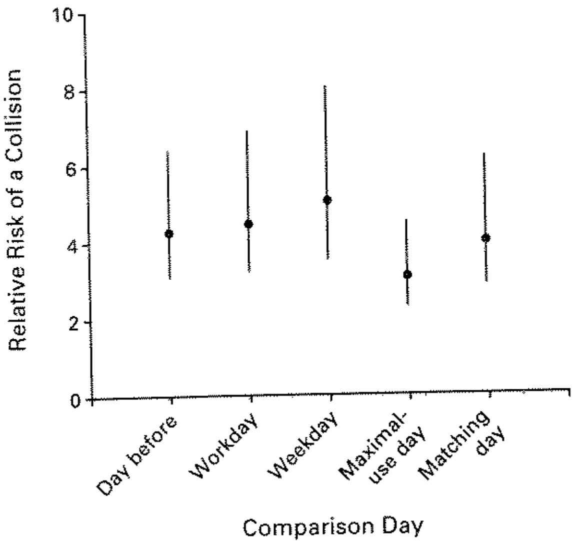


**Figure 1.** Relative Risk of a Collision for Different Control Periods.

Relative risks were calculated for five different control intervals. In the day-before comparison, we used the control period on the day immediately before the collision; in the workday comparison, the period on the preceding day of the workweek; in the weekday comparison, the period on the day one week before the collision; in the maximal-use-day comparison, the day with the most cellular-telephone activity of the three days preceding the collision; and in the matching-day comparison, the period on the nearest day of the preceding week in which there was cellular-telephone activity in the lead-up period. The vertical lines indicate 95 percent confidence intervals. Bars entirely above 1 indicate statistically significant associations (P<0.05).

**Table 2.** Relative Risk of a Motor Vehicle Collision in 10-Minute Periods, According to Selected Characteristics.*

| Characteristic | No. with Telephone Use in 10 Min before Collision | Relative Risk (95% CI) |
|---|---|---|
| All subjects | 170 | 4.3 (3.0–6.5) |
| Age (yr) | | |
| <25 | 21 | 6.5 (2.2–∞ ) |
| 25–39 | 95 | 4.4 (2.8–8.8) |
| 40–54 | 44 | 3.6 (2.1–8.7) |
| ≥55 | 10 | 3.3 (1.5–∞ ) |
| Sex | | |
| Male | 123 | 4.1 (2.8–6.4) |
| Female | 47 | 4.8 (2.6–14.0) |
| High-school graduation | | |
| Yes | 153 | 4.0 (2.9–6.2) |
| No | 17 | 9.8 (3.0–∞ ) |
| Type of job | | |
| Professional | 34 | 3.6 (2.0–10.0) |
| Other | 136 | 4.5 (3.1–7.4) |
| Driving experience (yr) | | |
| 0–9 | 40 | 6.2 (2.8–25.0) |
| 10–19 | 67 | 4.3 (2.6–10.0) |
| 20–29 | 36 | 3.0 (1.7–7.0) |
| ≥30 | 27 | 4.4 (2.1–17.0) |
| Cellular-telephone experience (yr) | | |
| 0 or 1 | 51 | 7.8 (3.8–32.0) |
| 2 or 3 | 39 | 4.0 (2.2–12.0) |
| 4 or 5 | 36 | 2.8 (1.7–6.7) |
| ≥6 | 44 | 4.1 (2.3–12.0) |
| Type of cellular telephone | | |
| Hand-held | 129 | 3.9 (2.7–6.1) |
| Hands free | 41 | 5.9 (2.9–24.0) |

*Relative risks indicate the probability of having a collision when using a cellular telephone at any time during a 10-minute interval as compared with the probability of having a collision when not using a cellular telephone at any time during a 10-minute interval. Relative risks have been adjusted to account for the intermittence of driving. CI denotes confidence interval.

were received on the collision days, of which the majority occurred after the event (68 percent and 64 percent, respectively). About 39 percent of the subjects used their cellular telephone at least once to contact emergency services immediately after the collision. The median number of calls made during the remainder of the day after the collision was substantially greater than the median number of calls made during an entire day before the collision (four vs. two, P<0.001). Of those who had not used their telephone on any day before the collision, 14 of 39 (36 percent) made at least one call in the aftermath of the event.

## DISCUSSION

We found that using a cellular telephone was associated with a risk of having a motor vehicle collision that was about four times as high as that among the same drivers when they were not using their cellular telephones. This relative risk is similar to the hazard associated with driving with a blood alcohol level at the legal limit.[29-31] We also found that cellular telephones have benefits, such as allowing drivers to make emergency calls quickly. A few drivers used their telephones only in the aftermath of a collision, thereby gaining some potential benefits and incurring no potential risks due to telephone use. In general, cellular-telephone calls were brief and infrequent, which explains why the rapid growth of this technology during recent years has not been accompanied by a dramatic increase in motor vehicle collisions.[32]

We observed no safety advantage to hands-free as compared with hand-held telephones. This finding was not explained by imbalances in the subjects' age, education, socioeconomic status, or other demographic characteristics. Nor can it be explained by suggesting that those with units that leave the hands free do more driving. One possibility is that motor vehicle collisions result from a driver's limitations with regard to attention rather than dexterity.[33] Regardless of the explanation, our data do not support the policy followed in some countries of restricting hand-held cellular telephones but not those that leave the hands free.

Three weaknesses of this study should be pointed

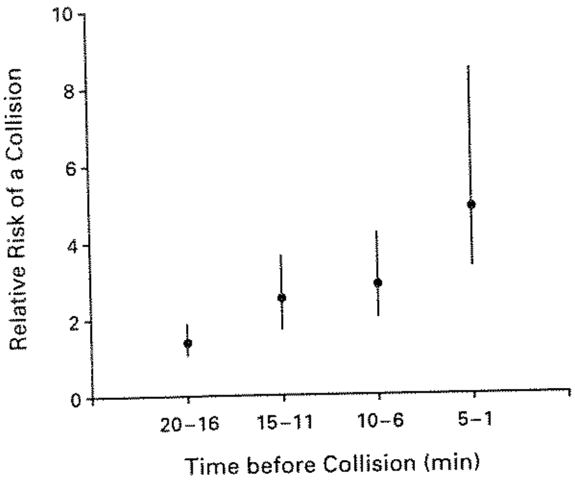


**Figure 2.** Time of Cellular-Telephone Call in Relation to the Relative Risk of a Collision.

Each minute before the collision was assessed as an independent hazard interval, with these intervals grouped in five-minute periods. Cellular-telephone activity for each hazard interval was evaluated in relation to the same period on the day before the collision. Relative risks greater than 1 indicate an association between telephone use and collisions. The vertical lines indicate 95 percent confidence intervals. Bars entirely above 1 indicate statistically significant associations ($P<0.05$). Calls made 1 to 5 minutes before the collision were significantly riskier than calls made 16 to 20 minutes before the collision ($P<0.001$).

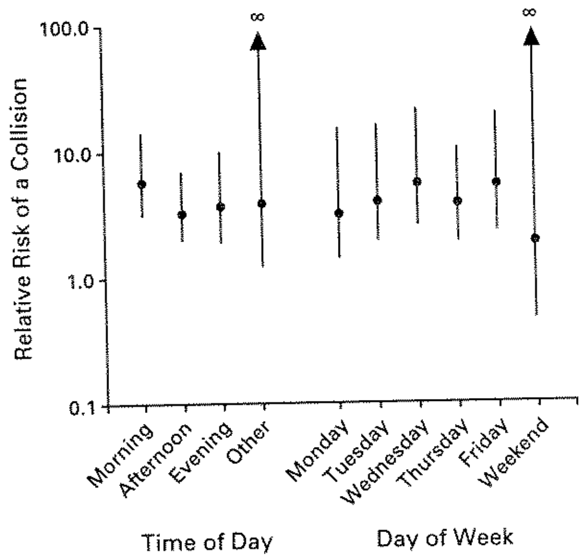


**Figure 3.** Consistency of Relative Risks Obtained from Different Collision Times.

The graph shows estimates of relative risk for collisions at different times of the day and of the week. Morning was defined as 8 a.m. to 11:59 a.m., afternoon as noon to 3:59 p.m., evening as 4 p.m. to 7:59 p.m., and other as all remaining times. Saturday and Sunday are combined in a single weekend category. The vertical lines indicate 95 percent confidence intervals. Bars entirely above 1 indicate statistically significant associations ($P<0.05$). The vertical scale is logarithmic.

out. First, we studied only drivers who consented to participate. The fact that some persons chose not to consent might have caused us to underestimate the risks associated with telephone use if these people declined because of concern about personal liability. Second, people vary in their driving behavior from day to day — a fact that makes the selection of a control period problematic. However, it would be difficult to explain all our findings on the basis of different driving patterns, and in particular, this factor would not account for the similar results for those who remembered driving during both periods on both days. Third, case–crossover analysis does not eliminate all forms of confounding. Imbalances in some temporary conditions related to the driver, the vehicle, or the environment are possible, but we believe such factors are not likely to account for the magnitude of the association we observed.

Our study indicates an association but not necessarily a causal relation between the use of cellular telephones while driving and a subsequent motor vehicle collision. For example, emotional stress may lead to both increased use of a cellular telephone and decreased driving ability. If so, individual calls may do nothing to alter the chances of a collision. In addition, our study did not include serious injuries; hence, we do not know how — or whether — cellular-telephone use is associated with motor vehicle fatalities. Finally, the data do not indicate that the drivers were at fault in the collisions; it may be that cellular telephones merely decrease a driver's ability to avoid a collision caused by someone else.

We caution against interpreting our data as showing that cellular telephones are harmful and that their use should be restricted. Even if a causal relation with motor vehicle collisions were to be established, drivers are vulnerable to other distractions that could offset the potential reductions in risk due to restricting the use of cellular telephones. Regulations would also mean reducing benefits; in Canada, for example, half a million calls to 911 emergency services are made from cellular telephones each year.[34] Yet proposals for regulation are not unreasonable, since poor driving imposes risks on others. Public debate is needed, given that cellular telephones contribute to improvements in productivity, the quality of life, and peace of mind for more than 30 million people in North America alone.

The role of regulation is controversial, but the role of individual responsibility is clear. Drivers who use a cellular telephone are at increased risk for a motor vehicle collision and should consider road-safety precautions. For them as for all other drivers, these include abstaining from alcohol, avoiding excessive speed, and minimizing other distractions. Additional strategies might include refraining from placing or receiving unnecessary calls, interrupting telephone conversations if necessary, and keeping calls brief — particularly in hazardous driving situations. Physicians should also learn to recognize patients who are at risk for a collision and who may benefit from advice regarding safety.[35-40] Even limited success in reducing risk may prevent some of the death, disability, and property damage related to motor vehicle collisions.

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## REFERENCES

1. Bureau of the Census. Statistical abstract of the United States 1995: the national data book. 115th ed. Washington, D.C.: Government Printing Office, 1995:92.
2. Canada year book 1994. Ottawa, Ont.: Statistics Canada, 1993:149.
3. Instituto Nacional de Estadistica Geografia e Informatica. Anuario Estadístico de los Estados Unidos Mexicanos 1993. Aguascalientes, Mexico: Instituto Nacional de Estadistica, Geografía e Informática 1994:568.
4. Rice DP, MacKenzie EJ, Associates. Cost of injury in the United States: a report to Congress 1989. San Francisco: Institute for Health and Aging, 1989:208.
5. Ontario road safety annual report 1994. Downsview, Ont.: Safety Research Office, Ministry of Transportation, 1996:2-4.
6. McFarland RA, Moore RC. Human factors in highway safety: a review and evaluation. N Engl J Med 1957;256:792-9.
7. U.S. wireless industry survey results: more than 9.6 million customers added in 1995. News release of the Cellular Telecommunications Industry Association, Washington, D.C., March 25, 1996:5.
8. Bureau of the Census. Statistical abstract of the United States 1995: the national data book. 115th ed. Washington, D.C.: Government Printing Office, 1995:849.
9. Violanti JM, Marshall JR. Cellular phones and traffic accidents: an epidemiological approach. Accid Anal Prev 1996;28:265-70.
10. Brown ID, Tickner AH, Simmonds DCV. Interference between concurrent tasks of driving and telephoning. J Appl Psychol 1969;53:419-24.
11. Alm H, Nilsson L. The effects of a mobile telephone task on driver behaviour in a car following situation. Accid Anal Prev 1995;27:707-15.
12. McKnight AJ, McKnight AS. The effect of cellular phone use upon driver attention. Accid Anal Prev 1993;25:259-65.
13. Brookhuis KA, de Vries G, de Waard D. The effects of mobile telephoning on driving performance. Accid Anal Prev 1991;23:309-16.
14. Stein AC, Parseghian Z, Allen RW. A simulator study of the safety implications of cellular mobile phone use. In: Proceedings of the 31st Annual Conference of the American Association for Automotive Medicine, New Orleans, September 28–30, 1987. Des Plaines, Ill.: American Association for Automotive Medicine, 1987:181-200.
15. Smith VJ. What about the customers? A survey of mobile telephone users. In: 28th IEEE Vehicular Technology Conference: conference record of papers presented at the 28th annual conference, Denver, March 22–24, 1978. New York: Institute of Electrical and Electronic Engineers, 1978:190-3.
16. Canete DW. AT&T cellular phone safety study: a survey of cellular phone owners located in the Baltimore/Washington, D.C., metropolitan area. Parsippany, N.J.: AT&T Consumer Products, 1985:1-62.
17. Maclure M. The case-crossover design: a method for studying transient effects on the risk of acute events. Am J Epidemiol 1991;133:144-53.
18. Mittleman MA, Maclure M, Robins JM. Control sampling strategies for case-crossover studies: an assessment of relative efficiency. Am J Epidemiol 1995;142:91-8.
19. Baker SP. Digit preference in reported time of collision. Accid Anal Prev 1971;3:77-80.
20. Efron B, Tibshirani R. Statistical data analysis in the computer age. Science 1991;253:390-5.
21. Breslow NE, Day NE. Statistical methods in cancer research. Vol. 1. The analysis of case-control studies. Lyon, France: International Agency for Research on Cancer, 1980:162-89. (IARC scientific publications no. 32.)
22. Marshall RJ, Jackson RT. Analysis of case-crossover designs. Stat Med 1993;12:2333-41.
23. Efron B. Bootstrap confidence intervals for a class of parametric problems. Biometrika 1985;72:45-58.
24. Better bootstrap confidence intervals. In: Efron B, Tibshirani R. An introduction to the bootstrap. New York: Chapman & Hall, 1993:178-201.
25. Scientific Advisory Group on Cellular Telephone Research. Assessing real world cellular phone usage patterns. Vol. 2. No. 2. Cellular Telephone Update. Winter 1994:3.
26. 1995 Annual report. Montreal: BCE Mobile Communications, 1996:53.
27. Annual report 1995. Toronto: Rogers Cantel Mobile Communications, 1996:32.
28. U.S. wireless industry survey results: more than 9.6 million customers added in 1995. News release of the Cellular Telecommunications Industry Association, Washington, D.C., March 25, 1996:4.
29. Smith HW, Popham RE. Blood alcohol levels in relation to driving. Can Med Assoc J 1951;65:325-8.
30. Simpson H. Polydrug effects and traffic safety. J Alcohol Drugs Driving 1985;1:17-44.
31. Vinson DC, Mabe N, Leonard LL, et al. Alcohol and injury: a case-crossover study. Arch Fam Med 1995;4:505-11.
32. Rothman KJ, Loughlin JE, Funch DP, Dreyer NA. Overall mortality of cellular telephone customers. Epidemiology 1996;7:303-5.
33. Kahneman D, Ben-Ishai R. Relation of a test of attention to road accidents. J Appl Psychol 1973;58:113-5.
34. Staying in touch: spring 1996. Etobicoke, Ont.: Bell Mobility, 1996:1.
35. Counseling to prevent motor vehicle injuries. In: Preventive Services Task Force. Guide to clinical preventive services. 2nd ed. Baltimore: Williams & Wilkins, 1996:643-57.
36. Prevention of motor vehicle accident injuries. In: The Canadian Task Force on the Periodic Health Examination. The Canadian guide to clinical preventive health care. Ottawa, Ont.: Canada Communication Group — Publishing, 1994:514-24.
37. Kelly RB. Effect of a brief physician intervention on seat belt use. J Fam Pract 1987;24:630-2.
38. Reisinger KS, Williams AF, Wells JK, John CE, Roberts TR, Podgainy HJ. Effect of pediatricians' counseling on infant restraint use. Pediatrics 1981;67:201-6.
39. Macknin ML, Gustafson C, Gassman J, Barich D. Office education by pediatricians to increase seat belt use. Am J Dis Child 1987;141:1305-7.
40. Redelmeier DA, Blair PJ. Survivors of motor vehicle trauma: an analysis of seat belt use and health care utilization. J Gen Intern Med 1993;8:199-203.

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# Papers

## Role of mobile phones in motor vehicle crashes resulting in hospital attendance: a case-crossover study

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### Abstract

**Objectives** To explore the effect of drivers' use of mobile (cell) phones on road safety.

**Design** A case-crossover study.

**Setting** Perth, Western Australia.

**Participants** 456 drivers aged ≥ 17 years who owned or used mobile phones and had been involved in road crashes necessitating hospital attendance between April 2002 and July 2004.

**Main outcome measure** Driver's use of mobile phone at estimated time of crash and on trips at the same time of day in the week before the crash. Interviews with drivers in hospital and phone company's records of phone use.

**Results** Driver's use of a mobile phone up to 10 minutes before a crash was associated with a fourfold increased likelihood of crashing (odds ratio 4.1, 95% confidence interval 2.2 to 7.7, $P < 0.001$). Risk was raised irrespective of whether or not a hands-free device was used (hands-free: 3.8, 1.8 to 8.0, $P < 0.001$; hand held: 4.9, 1.6 to 15.5, $P = 0.003$). Increased risk was similar in men and women and in drivers aged ≥ 30 and < 30 years. A third ($n = 21$) of calls before crashes and on trips during the previous week were reportedly on hand held phones.

**Conclusions** When drivers use a mobile phone there is an increased likelihood of a crash resulting in injury. Using a hands-free phone is not any safer.

### Introduction

Surveys indicate that drivers often talk on mobile (cell) phones. A 2004 observational survey of drivers of passenger vehicles in the United States indicated that at any given time of day 5% were talking on hand held phones.[1] Observational studies in other countries have reported lower rates of use.[2-4] Internationally, drivers report usually using hand held phones.[5-7] Because of concerns about risks of a potential crash, use of hand held phones is illegal in most countries in the European Union, all Australian states, the Canadian province of Newfoundland and Labrador, and New York, New Jersey, and the District of Columbia in the United States.

Most research on the safety implications of drivers' use of mobile phones has been experimental in design, involving small samples of volunteers. These studies have found that phone use impairs performance on simulated or instrumented driving tasks, using such measures as reaction time,[8-11] variability of lane position and speed,[10] following distance,[11] and situational awareness.[9 12] Impairments have resulted from cognitive distractions whether drivers are using either hands-free[8 9] or hand held[13 14] phones. Studies also have reported effects of physical distraction from handling phones.[15 16] It is unknown whether experimental findings are applicable to drivers using phones in their own vehicles.

A few epidemiological studies have assessed the risk of crashes associated with phone use. Police crash reports are not useful in this regard because information on the driver's phone use is unreliable. Two studies found modest increases in risk among drivers observed using hand held phones[17] and among more frequent versus less frequent users according to billing records from mobile phone companies.[7] Neither study examined phone use at the time of the crash. Using billing records to verify phone use by drivers involved in crashes that involved damage to property, Redelmeier and Tibshirani[18] compared phone use immediately before the crash with use during the previous week. The estimated risk of a crash while using phones was four times higher than when phones were not used. Hands-free phones seemed to offer no safety advantage over hand held phones, though few drivers had hands-free phones.

Important questions remain about the effects of phone use on the risk of a crash. These include whether use affects the risk of more serious crashes involving personal injuries and whether the risk differs for hands-free versus hand held phones. We studied drivers involved in injury crashes in Perth, Western Australia, where mobile phone company records could be obtained. Since 1 July 2001 it has been illegal to use a hand held phone when driving in Western Australia.

### Methods

We used a case-crossover design, a variation of a case-control design that is appropriate when a brief exposure (driver's phone use) causes a transient rise in the risk of a rare outcome (a crash). We compared a driver's use of a mobile phone at the estimated time of a crash with the same driver's use during another suitable time period. Because drivers are their own controls, the design controls for characteristics of the driver that may affect the risk of a crash but do not change over a short period of time. As it is important that risks during control periods and crash trips are similar, we compared phone activity during the hazard interval (time immediately before the crash) with phone activity during control intervals (equivalent times during which participants were driving but did not crash) in the previous week.

#### Study setting and participants

Participants were consenting drivers aged ≥17 years who were involved in a crash between April 2002 and July 2004, were seen





EXHIBIT

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in one of three main hospital emergency departments in the metropolitan area, and reported owning or using a mobile phone. Research officers recruited drivers in emergency departments from Monday to Friday between 8 am and 9 pm. We also included the few people who were admitted to hospital or remained in the emergency department after a weekend or overnight crash. We excluded motorcyclists and cyclists, those who sustained moderate or serious head injuries, those involved in crashes involving a fatality, and those with poor English. Drivers who were taken to hospital by ambulance were identified by using a real time automatic text messaging service from the sole road transport ambulance provider. Those who were transported by other means were identified through contact three times a day with hospitals during recruitment hours.

### Data collection

We interviewed drivers after medical or nursing staff permitted access and collected data on demographics, usual patterns of driving and mobile phone use, description of crash and preceding events (including phone use), and type of phone. We sought additional information regarding crashes and injuries from medical records. We accessed records of participants' mobile phone use for two hours before and after the crash as well as for the same time window during three control periods (24 hours, 72 hours, and 7 days before the crash). Phone activity was defined as calls made or received and text messages sent. Voice mail and text messages received were excluded unless drivers confirmed that they checked these while they were driving. Drivers reported what type of phone they used. If there was a hands-free device in the vehicle, irrespective of its use during the hazard and control periods, this was considered as hands-free phone use. Drivers were not asked what type of phone they used during the crash trip because of concerns about the veracity of responses and hospital concerns about legal issues because at the time it was illegal to use hand held phones while driving.

The three major telecommunication networks (Optus, Telstra, and Vodafone) provided records of relevant phone activity for consenting participants.

### Time of crash

Time of crash was estimated from several sources, including emergency response records, medical records, and self report from drivers interviewed in hospital; the latter sometimes included a review of call records stored on the drivers' phones. For most cases, we used the earliest reported time to reduce the misclassification of calls made after the crash as occurring before. We also compared data from the phone company with self reported data. In the event of discrepancies, we followed up participants by telephone and re-checked mobile phone data. If a participant reported a single call after the crash and mobile phone data recorded a single call that seemed to have been placed just before the crash, we assumed that the crash time was imprecise and the call was classified as after the crash. Thus, if this procedure biased the results, it would be expected to favour the null hypothesis that phone use was not associated with risk of crash.

### Hazard and control intervals

The hazard interval was defined as the 10 minute period before the crash. For drivers who had driven for less than 10 minutes when a crash occurred, we considered only the phone activity while the participant was driving on the assumption that activity before driving would not have influenced risk of a crash. We compared phone activity during a hazard interval with activity during control interval(s) of the same time and duration 24 hours, 72 hours, and 7 days before the crash when drivers confirmed, during the interview, that they had been driving. We analysed a hazard or control interval of up to 5 minutes to test the robustness of the results.

### Statistical analysis

Before the study started, we estimated the sample size using prevalence data from an observational survey.[2] We conducted matched analyses using conditional logistic regression to calculate the odds of having an injury crash in association with mobile phone use.[19] The primary analysis involved 1:multiple (1:M) matching[20]: phone use during the hazard interval for any driver was compared with between one and three control intervals depending on whether the driver reported driving during those control intervals. We excluded participants who denied driving during any control interval. Paired analyses were conducted as sensitivity analyses; a hazard interval was compared with a single control interval (24 hours, 72 hours, or 7 days) according to a participant's reported driving during each interval. We calculated odds ratios, 95% confidence intervals, and P values with Stata version 8 (StataCorp, College Station, TX). Subgroup analyses based on sex, age group, and phone type (hand held or hands-free) used 1:M matching. Odds ratios for subgroups were compared with a $\chi^2$ test with one degree of freedom.

## Results

Of 1625 drivers approached, 454 (28%) did not own or use mobile phones, 133 (8%) met another exclusion criterion, and 97 (6%) declined participation. The 941 (58%) remaining drivers were interviewed, and mobile phone activity records of 744 (79%) were available. Reasons for non-availability of records included refusal to allow access (n = 70), use of company phones (n = 47), phone data not accessible (n = 35), other owner (n = 24), and inability to recall phone number (n = 21). Among drivers with available phone records, 456 (61%) verified driving during at least one control interval. These were the study subjects and the basis of the case-crossover analyses. Tables 1 and 2 summarise characteristics of drivers and crashes for drivers who completed interviews, interviewed drivers with available phone records, and the case-crossover drivers.

Most participants (n = 423, 93%) had at least one injury and 44% (n = 201) had two or more. Injuries included sprains and strains (n = 252, 55%), haematomas and bruising (n = 149, 33%), abrasions and lacerations (n = 94, 21%), fractures and dislocations (n = 65, 14%), minor head injuries (n = 35, 8%), internal organ injuries to chest or abdomen (n = 14, 3%), and spinal injuries (n = 8, 2%). Injuries were predominantly mild to moderate in severity.

Despite owning or using mobile phones, 28% (n = 126) of participants said they never used the phone while driving. Of those (72%) who reported using a phone while driving, the proportion with hands-free devices ranged from 60% (n = 134) for those who occasionally used a phone while driving to 82% (n = 37) for those who often did.

In total, about half the participants (n = 238, 52%) reported having hands-free devices in their vehicles, including earpieces (n = 164, 36%), fully installed hands-free car kits (n = 45, 10%), headsets (n = 20, 4%), and speaker phones on handsets (n = 9, 2%; table 1). Only 6% (n = 29) had phones with voice activation features. Thirty drivers with a hands-free device in their vehicles (13%) said they never used a phone while driving; 159 (67%) reported using the hands-free device for phone activity when driving at least 90% of the time; and only 21 (9%) reported using

**Table 1** Characteristics of drivers based on interview. Figures are numbers (percentages) of participants

| | Drivers interviewed (n=941) | Drivers with phone activity records (n=744) | Drivers in case-crossover analysis* (n=456) |
|---|---|---|---|
| Men | 441 (46.9) | 335 (45.0) | 192 (42.1) |
| Age (years): | | | |
| 17-29 | 443 (47.1) | 356 (47.8) | 220 (48.2) |
| 30-49 | 340 (36.1) | 277 (37.2) | 169 (37.1) |
| >50 | 158 (16.8) | 111 (15.0) | 67 (14.7) |
| Driving experience (years): | | | |
| 0-9 | 438 (46.5) | 350 (47.0) | 217 (47.6) |
| 10-19 | 199 (21.1) | 167 (22.4) | 100 (21.9) |
| 20-29 | 145 (15.4) | 111 (14.9) | 71 (15.6) |
| ≥30 | 159 (16.9) | 116 (15.6) | 68 (14.9) |
| Type of mobile phone in vehicle: | | | |
| Hand held | 475 (50.5) | 373 (50.1) | 218 (47.8) |
| Fully installed hands-free kit | 103 (10.9) | 77 (10.3) | 45 (9.9) |
| Earpiece | 314 (33.4) | 250 (33.6) | 164 (35.9) |
| Headset | 35 (3.7) | 32 (4.3) | 20 (4.4) |
| Speaker phone on handset | 12 (1.3) | 11 (1.5) | 9 (2.0) |
| Other hands-free device | 2 (0.2) | 1 (0.1) | — |
| Mobile phone use while driving: | | | |
| Never use | 296 (31.5) | 229 (30.8) | 126 (27.6) |
| Occasionally use | 425 (45.2) | 352 (47.3) | 225 (49.3) |
| Sometimes use | 135 (14.3) | 94 (12.6) | 60 (13.2) |
| Frequently use | 85 (9.0) | 69 (9.3) | 45 (9.9) |
| Carrying phone on trip | 827 (87.9) | 666 (89.5) | 411 (90.1) |
| Reported using phone before crash | 72 (7.7) | 62 (8.3) | 32 (7.0) |
| Reported using phone after crash | 432 (45.9) | 358 (48.1) | 234 (51.3) |
| Regular weekly driving pattern | 678 (72.1) | 550 (73.9) | 362 (79.4) |
| Automatic transmission in vehicle | 471 (50.1) | 381 (51.2) | 228 (50.0) |

*Those with available records on mobile phone activity who reported driving during at least one control interval.

**Table 2** Characteristics of crashes. Figures are numbers (percentages) of participants

| | Drivers interviewed (n=941) | Drivers with phone activity records (n=744) | Drivers in case-crossover analysis* (n=456) |
|---|---|---|---|
| Day of crash: | | | |
| Monday | 154 (16.4) | 124 (16.7) | 73 (16.0) |
| Tuesday | 188 (20.0) | 142 (19.1) | 101 (22.1) |
| Wednesday | 174 (18.5) | 136 (18.3) | 86 (18.9) |
| Thursday | 174 (18.5) | 149 (20.0) | 94 (20.6) |
| Friday | 187 (19.9) | 145 (19.5) | 80 (17.5) |
| Saturday | 34 (3.6) | 24 (3.2) | 9 (2.0) |
| Sunday | 30 (3.2) | 24 (3.2) | 13 (2.9) |
| Time of crash (24 hour clock): | | | |
| 0500-0959 | 251 (26.7) | 202 (27.2) | 150 (32.9) |
| 1000-1459 | 283 (30.1) | 212 (28.5) | 122 (26.8) |
| 1500-1959 | 346 (36.8) | 281 (37.8) | 165 (36.2) |
| 2000-0459 | 61 (6.5) | 49 (6.6) | 19 (4.2) |
| Weather conditions: | | | |
| Fine | 686 (72.9) | 539 (72.4) | 330 (72.4) |
| Overcast | 147 (15.6) | 121 (16.3) | 81 (17.8) |
| Rain | 108 (11.5) | 84 (11.3) | 45 (9.9) |
| Trip length before crash (mins): | | | |
| ≤10 | 593 (63.0) | 479 (64.4) | 288 (63.2) |
| 11–60 | 318 (33.8) | 244 (32.8) | 159 (34.9) |
| >60 | 26 (2.8) | 17 (2.3) | 8 (1.8) |
| Unknown | 4 (0.4) | 4 (0.5) | 1 (0.2) |
| Vehicles involved: | | | |
| Single | 139 (14.8) | 108 (14.5) | 49 (10.7) |
| Multiple | 802 (85.2) | 636 (85.5) | 407 (89.3) |
| Site of crash impact: | | | |
| Rear end | 141 (15.0) | 112 (15.1) | 73 (16.0) |
| Front end | 504 (53.6) | 400 (53.8) | 247 (54.2) |
| Side impact | 104 (11.1) | 85 (11.4) | 46 (10.1) |
| Multiple impact | 112 (11.9) | 90 (12.1) | 63 (13.8) |
| Rollover, other | 45 (4.8) | 35 (4.7) | 17 (3.7) |
| Unknown | 35 (3.7) | 22 (3.0) | 10 (2.2) |
| Driver factors: | | | |
| Speed† | 155 (16.5) | 121 (16.3) | 64 (14.0) |
| Alcohol | 44 (4.7) | 36 (4.8) | 13 (2.9) |
| Drugs | 19 (2.0) | 15 (2.0) | 10 (2.2) |
| Fatigue | 30 (3.2) | 24 (3.2) | 15 (3.3) |

*Those with available mobile phone activity records who reported driving during at least one control interval.
†Defined as factor if at least one vehicle was reportedly exceeding posted speed limit.

it less than half the time. Thus, of drivers who had hands-free devices and reported using a phone while driving, almost all said they generally used these devices.

Most drivers (n=411, 90%) were carrying their mobile phones during the crash trips (table 1), and 7% (n=32) said they used the phone sometime during that trip. About half (n=234, 51%) reportedly used their phones at least once after crashing, most commonly to contact family members (n=152, 65%), friends (n=53, 23%), workplace (n=42, 18%), and emergency services (n=31, 13%).

Of the 456 participants, 192 (42%) had driven during one control interval, 183 (40%) had driven during two, and 81 (18%) had driven during all three. This resulted in 456 case intervals and 801 control intervals available for analysis with multiple control periods. Phone records indicated that 40 of the 456 subjects (9%) used mobile phones during the hazard interval (that is, up to 10 minutes before the crash). Phones were used during 3% (n=25) of the 801 multiple control intervals. Based on the reported availability of hands-free devices, about one third (n=13) of calls during the hazard interval and one third (n=8) of calls during control intervals were on hand held phones. Of drivers with hands-free devices who used their phones during the hazard interval, 89% (n=24) reported that they used their hands-free devices for phone activity when driving at least 90% of the time.

Mobile phone use within the period during and up to 10 minutes before the estimated time of the crash was associated with a fourfold increase in the likelihood of crashing (odds ratio 4.1, 95% confidence interval 2.2 to 7.7, P<0.001) (table 3). Similar results were obtained when we analysed only the interval up to 5 minutes before a crash (3.6, 1.8 to 7.0, P<0.001). Analyses with paired matching to compare the hazard interval with an equivalent single control interval also showed significant associations between mobile phone use and the likelihood of a crash, similar in magnitude to the association with 1:M matching (table 3).

Sex, age group, or type of mobile phone did not affect the association between phone use and risk of crash (P>0.05) (table 4). In particular, both hand held and hands-free phone use while driving was associated with increased risk (4.9, 1.6 to 15.5, P=0.003 *v* 3.8, 1.8 to 8.0, P<0.001, respectively).

## Discussion

A person using a mobile phone when driving is four times more likely to have a crash that will result in hospital attendance. Sex,

**Table 3** Risk of injury crash and use of mobile phone while driving

| Type of matching | Hazard interval (up to 10 minutes before crash) | | Control driving interval(s) | | Odds ratio (95% CI) |
|---|---|---|---|---|---|
| | Drivers using phones | All drivers | Drivers using phones | Total | |
| 1:M (multiple control intervals) | 40 | 456 | 25 | 801 | 4.1 (2.2 to 7.7) |
| 1:1 (24 hours before crash) | 26 | 248 | 10 | 248 | 3.7 (1.5 to 9.0) |
| 1:1 (72 hours before crash) | 15 | 227 | 4 | 227 | 4.7 (1.3 to 16.2) |
| 1:1 (7 days before crash) | 32 | 326 | 11 | 326 | 4.5 (1.9 to 10.9) |

age group, or availability of a hands-free device do not influence the increased likelihood of a crash. In this study, we measured the seriousness of crashes by participants' injuries; almost all had at least one injury and almost half had two or more.

### Comparison with other research

Some authors have suggested that drivers who use mobile phones while driving may inherently take more risks than other drivers.[17] This may be true, but the case-crossover design of this study controlled for risk taking and other characteristics of drivers that may affect risk but do not change over a short period of time.

Our findings are similar to those reported by Redelmeier and Tibshirani, whose case-crossover study found a fourfold increased risk of crashes that result in damage to property associated with phone use.[18] These similar findings occurred despite some notable differences in the methods of the studies. In our study we collected and reconciled, where possible, both drivers' reports of phone use before crashes and data from phone companies. Because of the higher proportion of drivers with hands-free devices in our study, we were able to estimate the risk of crashes associated with hands-free and hand held phones. We assumed that phone use could have influenced risk of crash only when participants were driving, and participants included only those drivers who reported in their initial interviews that they had been driving during at least one control interval. Redelmeier and Tibshirani did not initially collect information on driving during control intervals.[18] They adjusted estimates of risk based on information from a separate pilot study and from interviews with a small subset of participants conducted a year after the crash. Some researchers questioned whether these adjustments adequately addressed the issue.[21 22] While our approach did not remove the potential for recall bias, it probably reduced it. The lengths of hazard and corresponding control intervals in our study were not fixed, as used by Redelmeier and Tibshirani,[18] but varied up to 10 minutes according to the duration of the driving trip in which a crash occurred. As 63% (n = 288) of drivers reported a trip length of 10 minutes or less before crashing this could have been an important consideration.

### Limitations

The precise time of the crash may not be known with absolute certainty, and the possibility of misclassifying calls after the crash as those before the crash was a concern. We minimised misclassification bias by subsequent verification of self report and mobile phone records when these sources differed. This did not eliminate the possibility that for legal or social reasons participants said they had not used the phone before crashing. The overall effect of non-reporting would have been to bias the result toward the null hypothesis, thereby underestimating the risk of phone use. Participation rates were high, and we did not identify important differences among drivers who were interviewed, drivers whose phone records were obtained, and study participants. However, it is possible that drivers who refused to take part or refused access to phone records differed from our remaining participants. Again, the overall effect would have been to bias the result toward the null hypothesis.

We took care to verify that participants were driving during the hazard and control intervals, but circumstances of the control driving intervals may have differed from the crash driving interval, and the findings point to a statistical rather than causal association. Our results, however, reflect those reported by Redelmeier and Tibshirani,[18] as well as those from the numerous experimental studies.[8-12]

The distracting effects of different types of hands-free phones may not be equivalent—for example, searching for an earpiece to answer an incoming call may be more distracting than answering a phone mounted in a hands-free kit. Although voice activated units are becoming more common, only 6% of mobile phone users in our study had phones with this feature. The sample size was not large enough to assess whether certain types of hands-free devices, including fully hands-free, might be safer than other types.

### Policy implications

Mobile phone use while driving may result in physical or cognitive distraction. In an effort to minimise the effects of handling phones, many jurisdictions, including Western Australia, have laws prohibiting the use of hand held phones while driving. Although not based on rigorous sampling methods, periodic roadside observations conducted in Perth before, during, and after our study indicated that about 2% of drivers were illegally using hand held phones. Furthermore, 37% (n = 122) of participants who reported using phones while driving, at least on occasion, reported not having a hands-free device in their vehicle.

Studies of laws prohibiting use of hand held phones in the US found that such use declined significantly in the first few

**Table 4** Risk of injury crash and mobile phone use, using multiple control intervals, by sex, age group, and hands-free and hand held phones

| | Hazard interval (10 minutes before crash) | | Control driving interval(s) | | Odds ratio (95% CI) |
|---|---|---|---|---|---|
| | Drivers using phones | All drivers | Drivers using phones | Total | |
| Men | 19 | 192 | 13 | 352 | 5.2 (1.9 to 14.4) |
| Women | 21 | 264 | 12 | 449 | 3.5 (1.6 to 7.7) |
| Age group (years): | | | | | |
| <30 | 19 | 220 | 12 | 373 | 3.9 (1.6 to 9.4) |
| ≥30 | 21 | 236 | 13 | 428 | 4.3 (1.8 to 10.5) |
| Type of mobile phone: | | | | | |
| Hand held | 13 | 218 | 8 | 377 | 4.9 (1.6 to 15.5) |
| Hands-free | 27 | 238 | 17 | 424 | 3.8 (1.8 to 8.0) |

### What is already known on this topic

Many drivers use mobile phones while driving and laboratory based research has highlighted that this impairs driving performance

Epidemiological research has shown an association between phone use and increased risk of crashes that result in property damage

### What this paper adds

Use of mobile phones is associated with an increased likelihood of serious road crashes resulting in hospital attendance

The use of currently available hands-free devices does not seem to reduce the risk

months after the laws took effect.[23 24] In New York, use of hand held phones subsequently returned to levels seen before the law. Publicised enforcement campaigns may be needed to achieve long term compliance. Even full compliance, however, will not eliminate the risk of crashes. According to our study, there is no safety advantage associated with switching to the types of hands-free devices that are commonly in use.

Laws limiting all phone use while driving would be difficult to enforce. While a possible solution in the future is to change mobile phones so they cannot be used when vehicles are in motion, the likelihood the industry would embrace such a change seems remote. More and more new vehicles are being equipped with Bluetooth technology, facilitating voice activation and therefore totally hands-free phone use. Though this may lead to fewer hand held phones used while driving in the future, our research indicates that this may not remove the risk. Importantly, if this new technology actually increases mobile phone use in cars, it could contribute to even more crashes. At least in the short term, it seems likely that mobile phone use in cars will continue to grow, despite the growing evidence of the risk it creates.

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1 Glassbrenner D. *Driver cell phone use in 2004, overall results.* Washington, DC: US National Highway Traffic Safety Administration, 2005. (DOT HS-809-847.)
2 Horberry T, Bubnich C, Hartleyk L, Lamble D. Drivers' use of hand-held mobile phones in Western Australia. *Transportation Research Part F* 2001;4:213-8.
3 Johal S, Napier F, Britt-Compton J, Marshall T. Mobile phones and driving. *J Public Health Oxf* 2005;27:112-3.
4 Taylor DMcD, Bennett DM, Carter M, Garewal D. Mobile telephone use among Melbourne drivers: a preventable exposure to injury risk. *Med J Aust* 2003;179:140-2.
5 Royal D. *National survey of distracted and drowsy driving attitudes and behaviour: 2002. Vol 1. Findings.* Washington, DC: National Highway Traffic Safety Administration, 2003. (DOT HS-809-566.)
6 Sullman MJM, Baas PH. Mobile phone use amongst New Zealand drivers. *Transportation Research Part F* 2004;7:95-105.
7 Laberge-Nadeau C, Maag U, Bellavance F, Lesjardins D, Messier S, et al. Wireless telephones and the risk of road crashes. *Accid Anal Prev* 2003;35:649-60.
8 Consiglio W, Driscoll P, Witte M, Berg WP. Effect of cellular telephone conversations and other potential interference on reaction time in a braking response. *Accid Anal Prev* 2003;35:495-500.
9 Strayer DL, Drews FA, Johnston WA. Cell phone-induced failures of visual attention during simulated driving. *J Exp Psychol Appl* 2003;9:23-32.
10 Alm H, Nilsson L. Changes in driver behaviour as a function of hands free mobile phones—a simulator study. *Accid Anal Prev* 1994;26:441-51.
11 Alm H, Nilsson L. The effects of a mobile telephone task on driver behaviour in a car following situation. *Accid Anal Prev* 1995;27:707-15.
12 McKnight AJ, McKnight AS. The effect of cellular phone use upon driver attention. *Accid Anal Prev* 1993;25:259-65.
13 Haigney DE, Taylor RG, Westerman SJ. Concurrent mobile (cellular) phone use and driving performance: task demand characteristics and compensatory process. *Transportation Research Part F* 2000;3:113-21.
14 Matthews R, Legg S, Charlton S. The effect of cell phone type on drivers' subjective workload during concurrent driving and conversing. *Accid Anal Prev* 2003;35:451-7.
15 Brookhuis KA, DeVries G, DeWaard D. The effects of mobile telephoning on driver performance. *Accid Anal Prev* 1991;23:309-16.
16 Wikman A-S, Nieminen T, Summala H. Driving experience and time-sharing during in-car tasks on roads of different width. *Ergonomics* 1998;41:358-72.
17 Wilson J, Fang M, Wiggins S. Collision and violation involvement of drivers who use cellular telephones. *Traffic Inj Prev* 2003;4:45-52.
18 Redelmeier DA, Tibshirani RJ. Association between cellular telephone calls and motor vehicle collisions. *N Engl J Med* 1997;336:453-8.
19 Woodward M. *Epidemiology: study design and data analysis.* 2nd ed. Boca Raton, FL: Chapman and Hall/CRC Press, 2005.
20 Mittleman MA, Maclure M, Robins JM. Control sampling strategies for case-crossover studies: an assessment of relative efficiency. *Am J Epidemiol* 1995;142:91-8.
21 Maclure M, Mittleman MA. Cautions about car telephones and collisions. *N Engl J Med* 1997;336:501-2.
22 Goodman MJ, Tijerina L, Bents FD, Wierwille W. Using cellular telephones in vehicles: safe or unsafe? *Transportation Human Factors* 1999;1:3-42.
23 McCartt AT, Geary LL. Longer term effects of New York State's law on drivers' hand-held cell phone use. *Inj Prev* 2004;10:11-5.
24 McCartt AT, Hellinga LA, Geary LL. *Effects of Washington, DC, law on drivers' hand-held cell phone use.* Arlington, VA: Insurance Institute for Highway Safety, 2005.

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05-O-1090

**AN ORDINANCE BY**
**COUNCILMEMBER JIM MADDOX**
**AS SUBSTITUTED BY PUBLIC SAFETY**
**AND LEGAL ADMINISTRATION COMMITTEE**

**AN ORDINANCE TO AMEND CHAPTER 150 OF THE CODE OF ORDINANCE OF THE CITY OF ATLANTA BY CREATING A NEW SECTION 150-69 WHICH SHALL PROVIDE THAT IT SHALL BE UNLAWFUL TO USE A HAND-HELD MOBILE TELEPHONE WHILE OPERATING A MOTOR VEHICLE IN THE CITY OF ATLANTA; AND FOR OTHER PURPOSES**

**WHEREAS**, the use of mobile telephones has skyrocketed in recent years, with more than 117 million subscribers in the United States as of July 1, 2001; and

**WHEREAS**, this increase has been accompanied by an increase in the number of individuals concurrently driving and talking on the cell phone. Recent estimates suggest that cell phone users spend 60% of their cell phone time while driving; and

**WHEREAS**, research makes the tacit assumption that the source of any interference from cell phone use is due to peripheral factors such as dialing and holding the phone while conversing; and this assumption has been proven valid; and

**WHEREAS**, prior research has established that the use of mobile telephones impairs driving performance and is associated with an increased likelihood of serious road crashes. *See e.g.*, Donald A. Redelmeier, M.D., *Association Between Cellular-Telephone Calls and Motor Vehicle Collisions*, The New England Journal of Medicine, Volume 336, Number 7 (February 13, 1997), attached hereto as Exhibit "A"; Suzanne P. McEvoy, *Role of Mobile Phones in Motor Vehicle Crashes Resulting in Hospital Attendance: a Case-Crossover Study*, BMJ, doi:10.1136/bmj.38537.397512.55 (July 12, 2005), attached hereto as Exhibit "B".

**WHEREAS**, the idea of using hand free devices has been cautiously embraced by the cell phone industry. Some vendors, for example, encourage new buyers to use them for their own safety; and

**WHEREAS**, it is the sentiment of the Atlanta City Council that the banning of the use of handheld mobile telephones will decrease the incidence of traffic accidents and thereby improve the safety on the city's arteries; and

**WHEREAS**, similar legislation has been adopted in several states, as well as cities throughout the United States.

**BE IT ORDAINED BY THE COUNCIL OF THE CITY OF ATLANTA, GEORGIA** as follows:

Section 1: That Chapter 150 **General Rules of Vehicle Operation** of the Code of Ordinances of the City of Atlanta is hereby amended to create a new Section 150-69, to read:

**Section 150-69. Restricted use of mobile telephones.**

(a) For purposes of this section, the following terms shall mean:

(1) "Mobile telephone" means a cellular, analog, wireless, satellite or digital telephone capable of sending or receiving telephone messages without an access line for service.

(2) "Using" means holding a mobile telephone to, or in the immediate proximity of, the user's ear.

(3) "Hand-held mobile telephone" means a mobile telephone with which a user engages in a call using at least one hand.

(4) "Hands-free mobile telephone" means a mobile telephone that has an internal feature or function, or that is equipped with an attachment or addition, whether or not permanently part of such mobile telephone, by which a user engages in a call without the use of either hand, whether or not the use of either hand is necessary to activate, deactivate or initiate a function of such telephone.

(5) "Engage in a call" means talking into or listening on a hand-held mobile telephone, but shall not include holding a mobile telephone to activate, deactivate or initiate a function of such telephone.

(6) "Immediate proximity" means that distance as permits the operator of a mobile telephone to hear telecommunications transmitted over such mobile telephone, but shall not require physical contact with such operator's ear.

(b) Except as otherwise provided in this section, it shall be unlawful for any person to operate a motor vehicle upon any portion of the city's street system while using a mobile telephone to engage in a call while such vehicle is in motion.

(c) An operator of a motor vehicle who holds a mobile telephone to, or in the immediate proximity of his or her ear while such vehicle is in motion is presumed to be engaging in a call within the meaning of this section. The presumption established by this subsection is rebuttable by evidence tending to show that the operator was not engaged in a call.

(d) The provisions of this section shall not be construed as authorizing the seizure or forfeiture of a mobile telephone, unless otherwise provided by law or ordinance.

(e) Subsection (b) of this section shall not apply to:

(1) The use of a mobile telephone for the sole purpose of communicating with any of the following regarding an emergency situation: an emergency response operator; a hospital, physician's office or health clinic; an ambulance company or corps; a fire department, including any subdivision thereof; or a police department, including any subdivision thereof; or

(2) Any of the following persons while in the performance of their official duties: a police officer or peace officer; a member of a fire department; or the operator of an authorized emergency vehicle as defined in O.C.G.A. § 40-1-1(5); or

(3) The use of a hands-free mobile telephone.

(f) Any person who violates subsection (b) of this section shall be subject to a fine of $50.00, provided however, that if a violation occurs at the time of a traffic accident, the driver shall be subject to an additional fine not to exceed $200.00.

(g) In order to notify and educate the public as to the enactment of this ordinance, a sixty (60) day grace period from the ordinance's effective date shall be imposed. During such 60 day grace period, only warning citations shall be issued to persons violating subsection (b) of this section.

**Section 3:** That all ordinances and parts of ordinances in conflict herewith are hereby repealed.

CITY COUNCIL
ATLANTA, GEORGIA

**AN ORDINANCE** **05-O-1090**

Councilmember Jim Maddox

An Ordinance to amend Chapter 106 of the Code of Ordinances of the City of Atlanta so as to ban the use of hand-held cell phones while operating a motor vehicle in the City of Atlanta; and for other purposes

Whereas, the use of cellular phones has skyrocketed in recent years, with more than 117 million subscribers in the United States as of July 1, 2001; and

Whereas, this increase has been accompanied by an increase in the number of individuals concurrently driving and talking on the cell phone. Recent estimates suggest that cell phone users spend 60% of their cell phone time while driving; and

Whereas, research makes the tacit assumption that the source of any interference from cell phone use is due to peripheral factors such as dialing and holding the phone while conversing; and this assumption has been proven valid; and

Whereas, prior research has established that the manual manipulation of equipment (e.g., dialing the phone, answering the phone, etc.) has a negative impact on driving. However, the effects of the phone ***conversation*** on driving are not as well understood; and

.Whereas, the idea of using hand free devices has been cautiously embraced by the cell phone industry. Some vendors, for example encourage new buyers to use them for their own safety; and

Whereas, it is the sentiment of the Atlanta City Council that the banning of the use of handheld cell phones will decrease the incidence of traffic accidents and thereby improve the safety on the city's arteries; and

Whereas, similar legislation has been adopted in several states, as well as cities throughout the United States.

**BE IT ORDAINED BY THE COUNCIL OF THE CITY OF ATLANTA, GEORGIA** as follows:

Section 1: That Chapter 106 **Miscellaneous Offenses** of the Code of Ordinances of the City of Atlanta is hereby amended to create a new Section 60, to read:

**"Section 60: It shall be unlawful to use a hand held cellular telephone while operating a motor vehicle in the City of Atlanta."**

Section 2: Violation of this ordinance shall be punished as provided for in Section 1-8. of the Code of Ordinances.

Section 3: That all ordinances and parts of ordinances in conflict herewith are hereby repealed.